Synthesis of Field Observations and Multi-Scale Modeling of Aerosol Evolution

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Weather Research and Forecasting chemistry model (WRF-chem):

- **What is WRF-chem?** A fully-coupled meteorological-chemical-aerosol mesoscale model that includes aerosol direct and indirect forcing processes.
- **Why?** Since it is a community model, it provides a path to distribute aerosol modules developed under DOE support to many other atmospheric scientists. PNNL is a committee member and active contributor to the code. A global version now available, and now a framework to evaluate aerosol modules over local to global spatial scales.

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Effect of Anthropogenic Emission Rates on Simulated Particulate Evolution

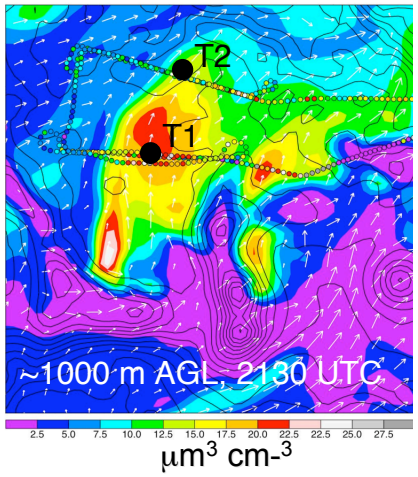
MILAGRO Modeling:

- **What are we doing?** Utilizing WRF-chem and MILAGRO data to quantify the sensitivity of predicted particulates to estimates of MCMA sources
- **Why?** Emission inventories are likely less certain in Mexico than in more developed countries and need to get primary quantities (OM, BC) right

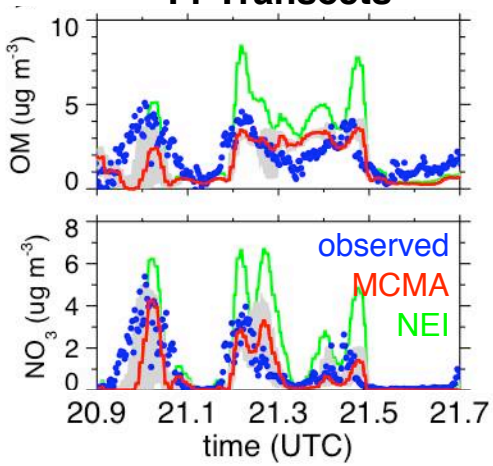
Results:

- Local, regional, and synoptic scale transport well predicted, but relatively larger errors in composition
- Predicted OM too high considering that the model currently neglects SOA
- Can POA be evaluated? At T0, predicted OM in better agreement with HOA than total OM. Is HOA volatile or nonvolatile?
- On-going collaboration with NCAR on SOA treatment in WRF-chem
- **Implications:** Too much POA for global modeling if these estimates were used.

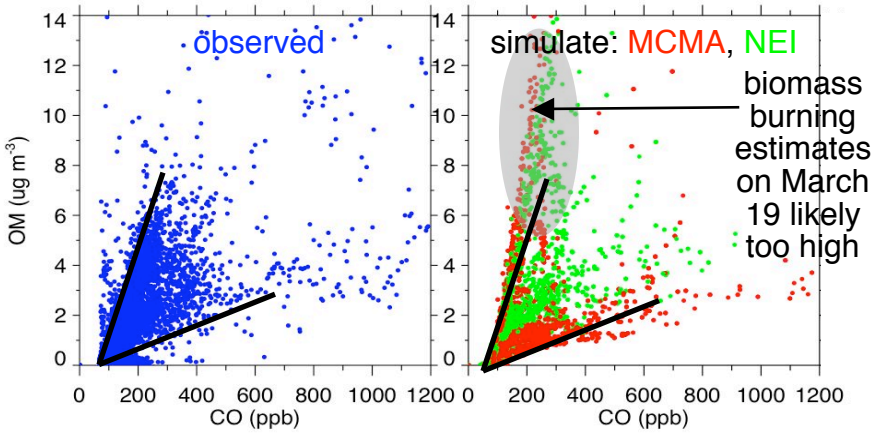
Particulate Volume



T1 Transects



OM and CO from Six G-1 flights March 18 - 22



[Kleinman et al.]

Effect of Anthropogenic Emission Rates on Simulated Extinction Profiles and AOD

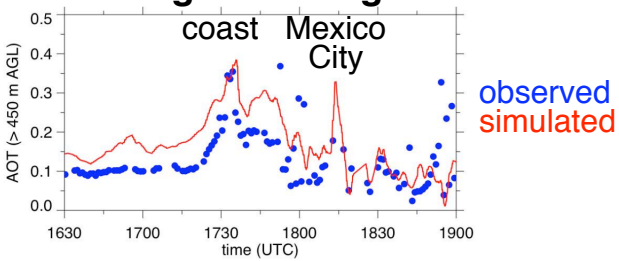
What about predicted AOD, given the uncertainties in particulates?

- **What are we doing?** Employing AOD data from Terra/Aqua satellites, AOD data from 7 surface sites, and extinction, backscatter, and depolarization profiles from HRSL when comparing with simulated values
- **Why?** Quantify how uncertainties in predicted particulate mass, composition, and size affect simulated aerosol radiative forcing

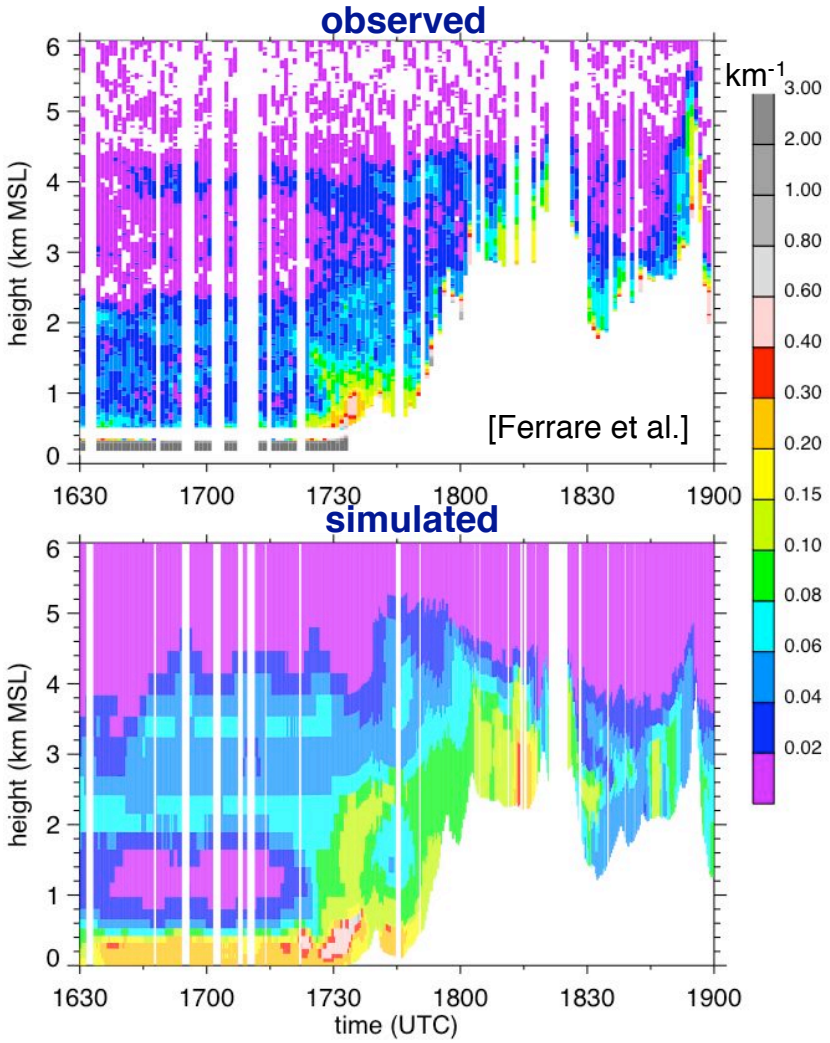
Results:

- Simulated spatial distribution of AOD is very good, but somewhat higher than observed
- "The right answer for the wrong reason"
- Aerosol water important over Gulf of Mexico
- **Implications:** What are the compensating errors in global climate models?

AOT along B-200 Flight Path



Extinction B-200 Path, 12 March 2006



Effect of Optical Property Treatments on Simulated Single Scattering Albedo

What about predicted SSA, given the uncertainties in particulates?

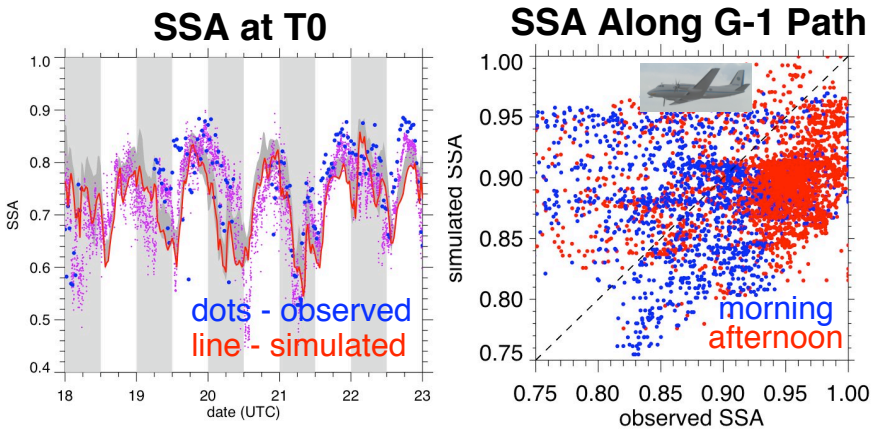
- **What are we doing?** Comparing predictions of SSA with scattering and absorption data
- **Why?** Quantify how uncertainties in predicted particulate mass, composition, and size affect simulated aerosol radiative forcing

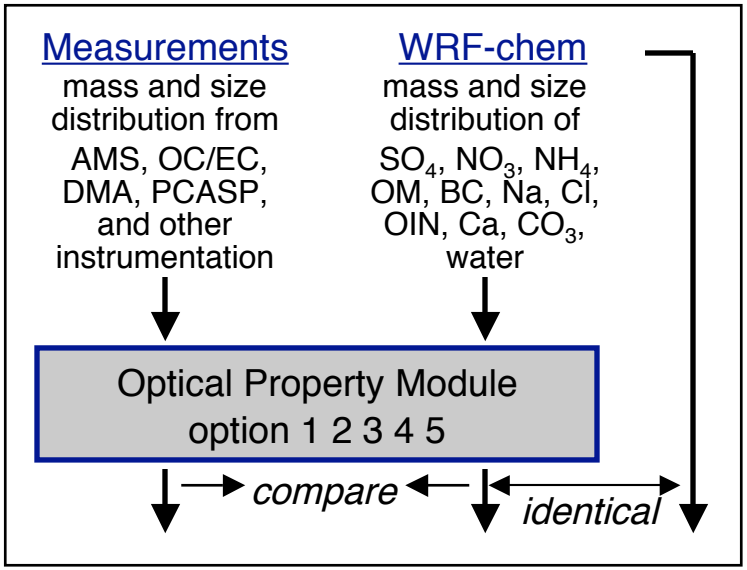
Results:

- Errors in simulated SSA > those for AOD
- Is the problem prediction of particulate mass, composition, and size distribution or the treatment of SSA in the model?
- Model dust likely to be too absorbing

Off-line Computations:

- Created an off-line version of optical property modules - driven by model output or data
- Sensitivity studies that use volume averaging, Maxwell-Garnett, and shell-core for the aerosol optical properties
- **Implications:** Improving SSA predictions very difficult as a result of uncertainties in data and many model parameters





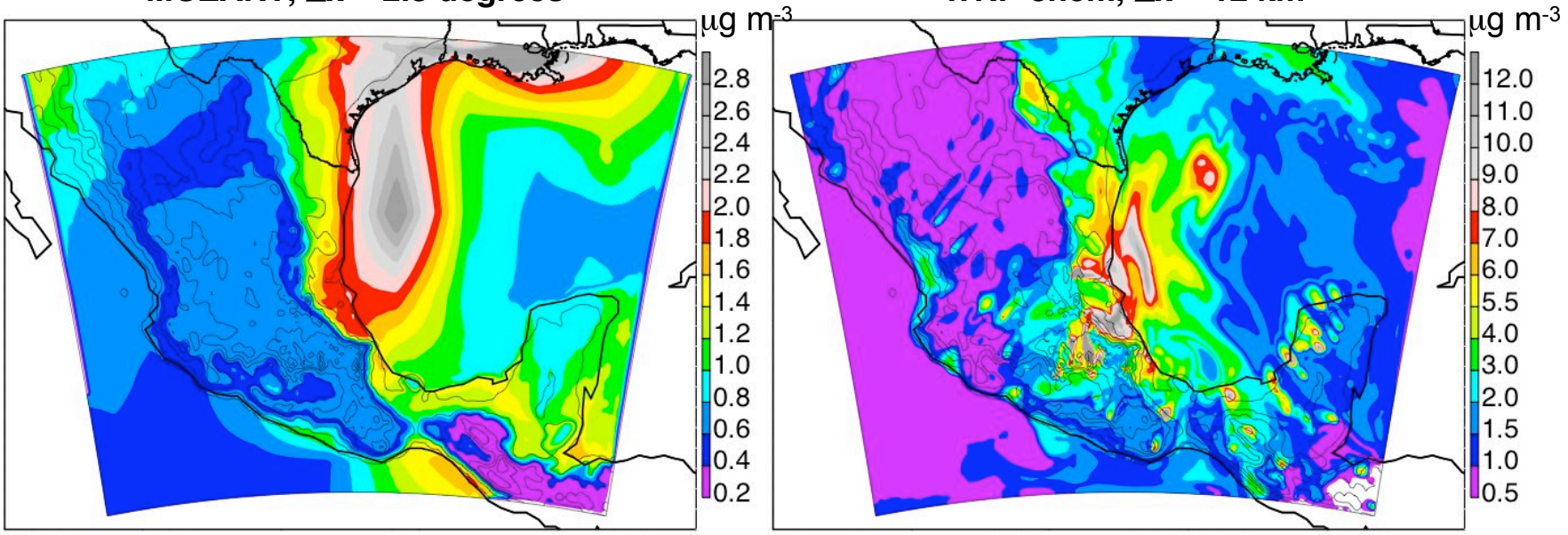
Quantifying Subgrid Scale Variability of Particulates & Aerosol Radiative Forcing

Utilizing MILAGRO for Parameterization Development:

- **What are we doing?** A series of sensitivity simulations will be performed to first quantify the effect of high resolution emissions and meteorology on particulate properties and aerosol radiative forcing when compared to spatial scales typically used by GCMs
- **Why?** Measurements and mesoscale model results both indicate strong local and regional gradients in particulates and aerosol radiative forcing. Is this important for GCMs? Can high-resolution simulations be used to develop a parameterized treatment of subgrid scale effects for GCMs?

Particulate Matter at 18 UTC March 19 ~ 1 km AGL

MOZART, Δx = 2.8 degrees | **WRF-chem, Δx = 12 km**



Transport Pathways of Point Sources and Their Impact on Cloud-Aerosol Interactions

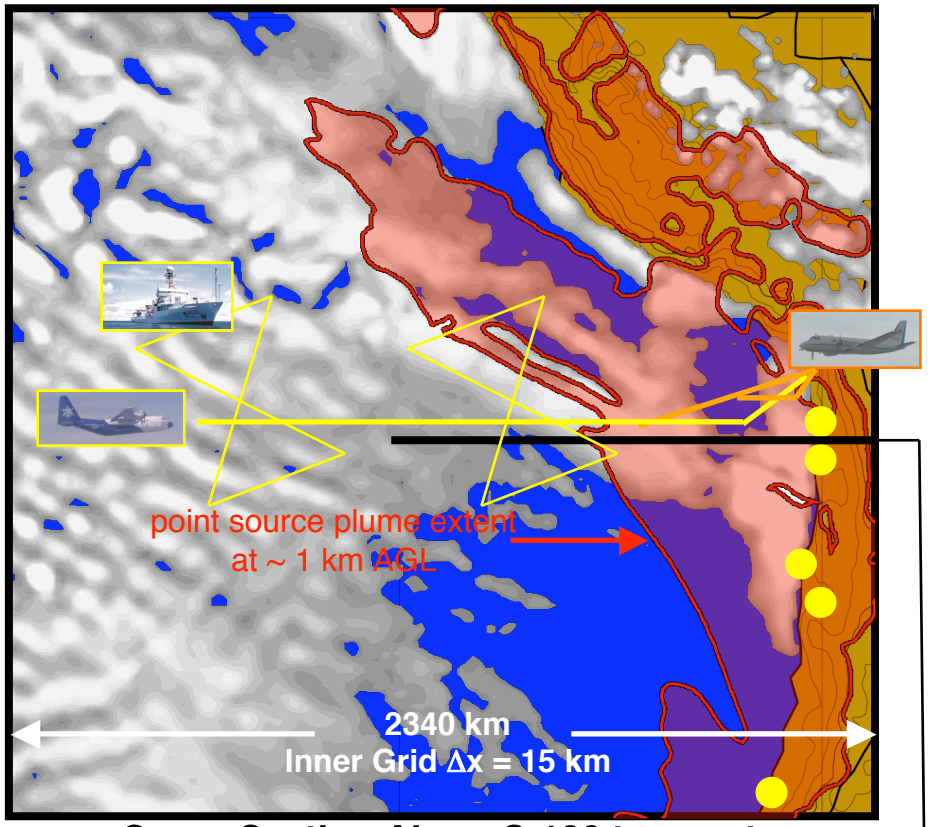
PreVOCA Exercise (UW):

- **What are we doing?** Participating in a regional and global model inter-comparison study to critically assess predictions of stratocumulus and aerosols over the SE Pacific Ocean
- **Why?** Use WRF-chem to determine transport pathways of point sources and understand uncertainties in the prediction of stratocumulus

Results:

- SO_2 from point sources transported hundreds of km west of coast
- Model performance in simulating stratocumulus clouds mixed
- Can use model results to evaluate aircraft flight sampling strategies
- Cloud-aerosol interactions reduce cloud amount, but is smaller than resolution and microphysics effects
- **Implications:** What is more important for climate modeling? (challenging)

Simulated COD, 12 UTC October 15, 2006



Cross-Section Along C-130 transect